PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 20 April 2000 (20.04.00)	
International application No. PCT/EP99/06556	**Applicant's or agent's file reference** PF980059
International filing date (day/month/year) 06 September 1999 (06.09.99)	**Priority date** (day/month/year) 07 September 1998 (07.09.98)
Applicant CHEVANCE, Christophe et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

21 March 2000 (21.03.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer F. Baechler
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

A.D

PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
PF980059		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 99/ 06556	06/09/1999	07/09/1998
Applicant		
THOMSON MULTIMEDIA et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 99/06556

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06T7/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 193 001 A (KERDRANVRAT MICHEL) 9 March 1993 (1993-03-09)	1,2,12
A	abstract column 2, line 9 - line 21 column 2, line 30 - line 48 column 6, line 16 - line 42	3-6,10

[ ] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 December 1999	23/12/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	González Arias, P

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 99/06556

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5193001 A	09-03-1993	FR 2648979 A	28-12-1990
		AT 141700 T	15-09-1996
		DE 69028160 D	26-09-1996
		DE 69028160 T	06-03-1997
		EP 0406074 A	02-01-1991
		ES 2092496 T	01-12-1996
		WO 9100577 A	10-01-1991
		JP 4500423 T	23-01-1992

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

RUELLAN LEMONNIER, Brigitte
THOMSON MULTIMEDIA
46 Quai Alphonse Le Gallo
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FRANCE

FBRA

THOMSON multimedia
RECEIVED
20 NOV. 2000
Patent Department
Administration - Paris

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NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Applicant's or agent's file reference PF980059	Date of mailing *(day/month/year)* 17.11.2000 **IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/06556	06/09/1999	07/09/1998

Applicant
THOMSON MULTIMEDIA et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Corcos, E Tel.+49 89 2399-7418

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PF980059		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/06556	06/09/1999	07/09/1998
International Patent Classification (IPC) or national classification and IPC G06T7/20		
Applicant THOMSON MULTIMEDIA et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21/03/2000	17.11.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Herter, J Telephone No. +49 89 2399 7478

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/06556

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-8	as originally filed				

Claims, No.:

1-13	as received on	11/10/2000	with letter of	10/10/2000	

Drawings, sheets:

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☒ the claims, Nos.: 14

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-13
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-13
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-13
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

1. Reference is made to the following document:

   D1: US-A-5 193 001 (Kerdranvrat Michel) 9 March 1993

2. **Item V: Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

   The present application meets the requirements of Article 33(2) PCT because the subject matter of claim 1 is novel and involves an inventive step in the sense of Article 33(3) PCT, the reasons being as follows:

   As to claim 1:
   D1 discloses:
   - Method of movement estimation for a sequence of images (see column 2, lines 30-34) including
   - segmentation of the video image into image blocks (see column 2, lines 36-37),
   - movement estimation per image block in order to obtain a movement vector field for said current image (see column 2, lines 37-39),
   - a stage of reassignment of a vector to a block by selecting one movement vector from among N predominant vectors (see column 2, lines 40-48), characterized in that
   - the predominant vectors are the ones of a group of vectors belonging to the movement vector field of said current image and at least to the movement vector field of a preceding image (see column 2, lines 40-48 supported by column 2, lines 30-34 and column 3, lines 31-39),

   D1, however, does not disclose:
   - the vectors being scaled according to the temporal distance to which they correspond.

   This last feature is not disclosed in any of the available prior art. An inventive step (Article 33(3) PCT) can be acknowledged.

3. **Item VII: Certain defects in the international application**

Although claim 1 is drafted in the two-part form the features "the predominant vectors are the ones of a group of vectors belonging to the movement vector field of said current image and at least to the movement vector field of a preceding image" is incorrectly placed in the characterising portion, as it is disclosed in document **D1** in combination with the features placed in the preamble (Rule 6.3(b) PCT).

The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document **D1** is not mentioned in the description, nor is this documents identified therein.

The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT. Care should be taken during revision, especially of the introductory portion including any statements of problem or advantages, not to add subject-matter which extends beyond the content of the application as originally filed (Article 34(2)(b) PCT).

Claims

1. Method of movement estimation including segmentation of the video image into image blocks, movement estimation per image block in order to obtain a movement vector field, characterized in that it includes a stage of reassignment of a vector to a block by selecting one movement vector from among N predominant vectors belonging to the vector field.

2. Method according to Claim 1, characterized in that, for a predominant vector, second-order regional maxima are detected so as not to be taken into account during the selection of the other predominant vectors.

3. Method according to Claim 1, characterized in that the predominant vectors are selected in each of the four directions.

4. Method according to Claim 1, characterized in that the selection of the reassigned vector is based on the value of the inter-displaced-image difference (DFD).

5. Method according to Claim 4, characterized in that, if the DFDs associated with the N predominant vectors are greater than the DFD associated with the original vector, the zero vector is adopted.

6. Method according to Claim 4, characterized in that, if the DFDs associated with the N predominant vectors are greater than the weighted DFD associated with the original vector, the original vector is kept.

7. Method according to Claim 1, characterized in that the selection of the reassigned vector is based on the calculation of the activity (spatial gradient) in the inter-image difference block (current block - estimated block).

8. Method according to Claim 7, characterized in that, if the activities corresponding to the N predominant vectors are greater than the activity corresponding to the original vector, the zero vector is adopted.

9. Method according to Claim 7, characterized in that, if the activities corresponding to the N predomi-

nant vectors are greater than the weighted activity corresponding to the original vector, the original vector is kept.

10. Method according to Claim 4, characterized in that the components of the vectors used during the DFD calculations are the spatially filtered components.

11. Method according to Claim 7, characterized in that the components of the vectors used during the spatial-gradient calculations are the spatially filtered components.

12. Method according to Claim 1, characterized in that, for each image, the predominant vectors are chosen from among the field of vectors of the current image and the field of vectors of at least one preceding image.

13. Method according to Claim 12, characterized in that the vectors of the preceding images, in addition to being scaled, are weighted as a function of the temporal distance.

14. Method according to Claim 12, characterized in that, when a break in movement is detected, the vectors of the preceding images are not considered.

RH

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G06T — A2

(11) International Publication Number: **WO 00/14682**

(43) International Publication Date: 16 March 2000 (16.03.00)

(21) International Application Number: PCT/EP99/06556

(22) International Filing Date: 6 September 1999 (06.09.99)

(30) Priority Data:
98/11140 7 September 1998 (07.09.98) FR

(71) Applicant *(for all designated States except US)*: THOMSON MULTIMEDIA [FR/FR]; 46, quai Alphonse Le Gallo, F–92100 Boulogne Billancourt (FR).

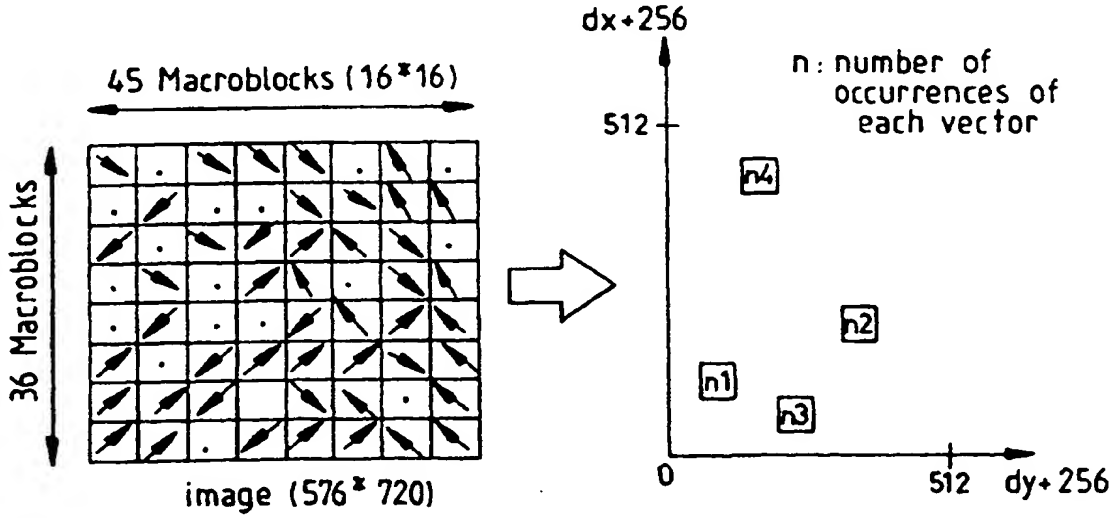
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: CHEVANCE, Christophe [FR/FR]; Thomson Multimedia, 46, quai Alphonse Le Gallo, F–92100 Boulogne Billancourt (FR). RUELLOU, Pierre [FR/FR]; Thomson Multimedia, 46, quai Alphonse le Gallo, F–92100 Boulogne Billancourt (FR). THOREAU, Dominique [FR/FR]; Thomson Multimedia, 46, quai Alphonse le Gallo, F–92100 Boulogne Billancourt (FR).

(74) Agent: RUELLAN LEMONNIER, Brigitte; Thomson Multimedia, 46, quai Alphonse Le Gallo, F–92100 Boulogne Billancourt (FR).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD OF MOTION ESTIMATION FOR TRANSMISSION COST REDUCTION OF MOTION VECTORS



(57) Abstract

The method includes segmentation of the video image into image blocks, movement estimation per image block in order to obtain a field of movement vectors. It is characterized in that it includes a stage of reassignment of a vector to a block by selecting one movement vector from among N predominant vectors belonging to the field of vectors. The applications relate to movement estimation, for example, by image–block matching.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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METHOD OF MOTION ESTIMATION FOR TRANSMISSION COST REDUCTION OF MOTION VECTORS

The invention relates to a method of movement estimation applied to MPEG-type video coding.

The majority of movement-estimation algorithms implemented in video coding use the technique of "block matching".

The image is segmented into blocks of size N*N, called macroblocks, and the estimator searches for the vector minimizing the difference between a block of the current image and a block of the reference image. This difference is generally an MSE (Mean Square Difference) or MAE (Mean Absolute Difference) calculated on the luminance pixels.

This type of estimator can supply a heterogeneous movement field since it is based on the variations of luminance and not on the actual movement in the sequence. This may entail an overhead for the coding of the vectors by the coder, the coding generally being of differential type, and thus a reduction in performance.

The object of the invention is to remedy the abovementioned drawbacks.

Its subject is a method of movement estimation including segmentation of the video image into image blocks, movement estimation per image block in order to obtain a movement vector field, characterized in that it includes a stage of reassignment of a vector to a block by selecting one movement vector from among N predominant vectors belonging to the vector field.

According to one particular implementation, for a predominant vector, second-order regional maxima are detected so as not to be taken into account during the selection of the other predominant vectors.

According to another implementation, the predominant vectors are selected in each of the four directions.

According to a particular implementation of the method, the selection of the reassigned vector is based on the value of the inter-displaced-image difference (DFD).

A particular characteristic of the invention consists in adopting the zero vector if the DFDs associated with the N predominant vectors are greater than the DFD associated with the original vector, or in actually keeping the original vector if the DFDs associated with the N predominant vectors are greater than the weighted DFD associated with the original vector.

According to another implementation of the method, the selection of the reassigned vector is based on the calculation of the activity (spatial gradient) in the inter-image difference block (current block - estimated block). If the activities corresponding to the N predominant vectors are greater than the activity corresponding to the original vector, the zero vector is adopted. If the activities corresponding to the N predominant vectors are greater than the weighted activity corresponding to the original vector, the original vector is kept.

According to another particular implementation of the method, for each image, the predominant vectors are chosen from among the field of vectors of the current image and the field of vectors of at least one preceding image.

By virtue of the invention, the movement vector fields calculated by an estimator of the "block matching" type can be homogenized.

The characteristics and advantages of the invention will emerge better from the following description, given by way of example and by reference to the attached figures, in which:

- Figure 1 represents a histogram of the movement vectors,
- Figure 2 represents a regional-maxima search window,

- Figure 3 represents an example of median filtering,

- Figure 4 represents an example of the preceding image vectors being taken into account,

- Figure 5 represents movement-vector fields during a zoom,

- Figure 6 represents various types of movement which may be detected.

The homogenization of the vector field is obtained via a method of conditional reassignment.

The vectors, associated with the images of a sequence, are calculated and stored by the estimator.

In order to carry out processing on the vectors, a two-dimensional histogram is constructed with dimensions of 512*512 in which the coordinates represent the values (dx, dy) which are the values of the horizontal and vertical components of these vectors.

Figure 1 represents, on the left-hand part, an image consisting of macroblocks to which the movement vectors are allocated and, on the right-hand part, the corresponding histogram.

Choice of predominant vectors

In order to make the movement field more homogeneous, the idea is to adopt a certain number of vectors, which is fixed in the first place by the user. This number will be larger in proportion to the heterogeneity of the movements.

The first solution consists in adopting the N vectors corresponding to the highest frequencies of appearance.

Another possibility is to stipulate that the algorithm choose N/4 predominant vectors in each of the four orientation planes. This solution can be adopted as an option, as an output criterion upon detection of zoom in the sequence. This is because such a phenomenon entails distribution in all directions of the vector field.

The last solution envisaged is to carry out detection of the regional maxima. This is because the

problem, in the first solution, is that it is possible to have several contiguous maxima, which do not confer enormous advantages compared with the fact of adopting fewer of them.

The histogram is therefore scanned, rejecting those vectors among the N predominant vectors appearing in the vicinity of other more predominant vectors. Thus the existence of these second-order maxima is identified by looking at the histogram to see whether two maxima lie in the same window, for example with dimensions 3*3.

Figure 2 represents such a window, referenced 1, for searching for regional maxima, this window being centred around the predominant vector adopted (dX, dY), the number of occurrences of which is n.

Choice of the vector allocated to a macroblock MB. Reassignment

- Method of the DFD

Once the predominant vectors have been extracted, a criterion remains to be found for reassigning each of these vectors to each MB. Since the movement estimator uses the criterion of the minimum DFD (Displaced-Frame Difference) to calculate the movement vectors, it seems useful to use this criterion to find the best possible correspondence between the vectors adopted and the macroblocks of the image to be processed.

After ordering the vectors in increasing order of their frequency of appearance, the calculation of DFD associated with each of these vectors is carried out for each MB. This calculation can be expressed simply by the following formula:

$$Dfd(i,j)=\sum_{k=0}^{N-1}\sum_{l=0}^{N-1}\left| MBCurrent(i+k,j+l)-MBReference(i+k+dy,j+l+dx)\right|$$

in which (i, j) are the coordinates of the MB to be processed;

N (= 16) is the size of the MB;

(dx, dy) are the components of the vector to be tested, belonging to [-128; +127.5].

It is important, before applying this formula, to check that the vector to be tested does not point outside the reference image. If no vector is suitable, then the zero vector is assigned.

Hence the vector corresponding to the minimum DFD is assigned to each MB.

- Gradient method

This consists in seeking, for each MB of the "difference" image consisting of the predicted reference image and of the current image, the vector corresponding to the minimum gradient which gives information on the local activity of the MB (of horizontal and vertical gradient type).

$$MB\_gradient = \sum_{\substack{4\,luma \\ blocks}} block\_active$$

with:

$$block\_active = MAX\left(\max_{i,j=0}^{i=6,j=7} |x(i,j) - x(i+1,j)|, \max_{i,j=0}^{i=7,j=6} |x(i,j) - x(i,j+1)| \right)$$

Enhancement of the reassignment

DFD/Gradient criterion

In order to keep certain movements, relating to objects of small size, the following criterion is defined:

If, after application of the DFD method, the vector adopted for an MB generates a DFD greater than the weighted original DFD, the original vector is kept.

Likewise, regarding the method of the gradient, for each MB obtained after inter-image difference, the gradient obtained by reassignment is compared with the gradient of the original vector. If the weighted original gradient is less than the new gradient, the original vector is kept.

Filtering applied to the movement vectors

In order to make the vector fields more homogeneous, other criteria may be used, namely spatial or temporal filtering.

- Spatial filtering

The filter adopted is the two-dimensional 3*3 median filter:

the principle is explained below in the light of Figure 3 which represents an image referenced 2 before filtering and an image referenced 3 after filtering. The vector referenced 4 is the vector to be processed.

The vertical and horizontal neighbours of the components of the MB in question are ordered along each direction (dx, dy), then the median value of each component is taken. Next the various DFDs associated with each MB are compared, in the case in which either one component is filtered, or both, or no component is filtered. Hence the vector corresponding to the minimum DFD is chosen, the original DFD, obviously, being weighted.

- Temporal filtering

The idea of temporal coherence is to take account, in the reassignment of the vectors of an image, of the movement fields of the preceding images; this is done with a view to limiting the disparity in the movements from one image to another.

To begin with, we will detail the principle of temporal filtering of Forward vectors (deferred-movement vectors).

Spatio-temporal histogram of Forward vectors:

In order to take account of the various histograms, scaling of the vectors is carried out at a first stage, then weighting of the occurrences which is a function of the position of the various histograms with respect to the histogram processed.

Hence, for the P image of Figure 4, it is possible to add to the histogram of original vectors, the occurrences of which have been weighted by a factor 3,

the occurrences of the vectors of the first B (the amplitude of which has been multiplied by 3) which are weighted by a factor 1 as well as the occurrences of the vectors of the second B (the amplitude of which has been multiplied by 3/2) which are weighted by a factor 2.

Temporal coherence should be relevant when uniform movements are present, and breaks in movement (change of scene) are not present.

Case of Backward vectors (anticipated-movement vectors)

It would be logical to think that, if there are uniform "Forward" movements from one image to the next, they would also be present in the case of the "Backward" vectors associated with the B images. In order to filter the latter, it must not be forgotten that the Backward vectors are based on the P or the I which will follow the B in question. Hence, for the first B, it may be thought that its Backward vectors will be twice as large as the Backward vectors associated with the second B. Scaling is carried out on the vectors of the latter by a factor of 2, and the weighted occurrences will be added, in the histogram associated with the first B.

Detection of uniform field

The idea of applying the reassignment with N vectors on sequences with multidirectional movements such as a zoom, for example, is not relevant. This is because, in this fairly specific case, the fact of adopting only N predominant vectors does not make it possible conveniently to process the fields consisting of multiple vectors.

Figure 5 represents the image of the vectors during the zoom. It can easily be seen that the disparity in the field does not allow any such uniformity.

It is therefore decided to detect, in the first place, a field in which the vectors are uniformly distributed, either unilaterally, or in all directions (zoom). This detection is conveyed by a standard devia-

tion of the first predominant vector close to the average standard deviation calculated from among the N predominant vectors. This is expressed as:

if $\sigma 1 \leq threshold * \sigma average \Rightarrow$ *uniform field present*

in which the threshold is fixed by the user (threshold = 1.34 for example).

Examples relating to the types of movements which are successfully detected are represented in Figures 6a, b, c, d.

The objective is, at present, not to apply the algorithm when cases (c) and (d) are present. These cases have still to be distinguished from cases (a) and (b). To do that the average values of the dx and dy movements are examined, from among the N adopted, and it is seen whether they are close to zero. This is because it may be observed that the movements in a zoom seem to cancel out if they are added, in contrast to unilateral movement. A maximum difference of five pixels can be set for dx, dy.

Limitation on the temporal filtering

It is useful not to have to filter the histograms temporally in the event of breaks in movement. It is possible:

- to store the histogram of initial or reassigned vectors for a P-type image;
- at the next P-type image, P (t), the new "image" vectors are compared. If they differ too much from their counterparts arising from P (t - n), the original vectors are kept.

Choice of the Number of Predominant Vectors

The number of vectors necessary may be decided automatically and dynamically, in such a way that, for sequences with random movements (for example a sporting sequence), there are more vectors than for sequences with uniform movements ("train").

Claims

1. Method of movement estimation including segmentation of the video image into image blocks, movement estimation per image block in order to obtain a movement vector field, characterized in that it includes a stage of reassignment of a vector to a block by selecting one movement vector from among N predominant vectors belonging to the vector field.

2. Method according to Claim 1, characterized in that, for a predominant vector, second-order regional maxima are detected so as not to be taken into account during the selection of the other predominant vectors.

3. Method according to Claim 1, characterized in that the predominant vectors are selected in each of the four directions.

4. Method according to Claim 1, characterized in that the selection of the reassigned vector is based on the value of the inter-displaced-image difference (DFD).

5. Method according to Claim 4, characterized in that, if the DFDs associated with the N predominant vectors are greater than the DFD associated with the original vector, the zero vector is adopted.

6. Method according to Claim 4, characterized in that, if the DFDs associated with the N predominant vectors are greater than the weighted DFD associated with the original vector, the original vector is kept.

7. Method according to Claim 1, characterized in that the selection of the reassigned vector is based on the calculation of the activity (spatial gradient) in the inter-image difference block (current block - estimated block).

8. Method according to Claim 7, characterized in that, if the activities corresponding to the N predominant vectors are greater than the activity corresponding to the original vector, the zero vector is adopted.

9. Method according to Claim 7, characterized in that, if the activities corresponding to the N predomi-

nant vectors are greater than the weighted activity corresponding to the original vector, the original vector is kept.

10. Method according to Claim 4, characterized in that the components of the vectors used during the DFD calculations are the spatially filtered components.

11. Method according to Claim 7, characterized in that the components of the vectors used during the spatial-gradient calculations are the spatially filtered components.

12. Method according to Claim 1, characterized in that, for each image, the predominant vectors are chosen from among the field of vectors of the current image and the field of vectors of at least one preceding image.

13. Method according to Claim 12, characterized in that the vectors of the preceding images, in addition to being scaled, are weighted as a function of the temporal distance.

14. Method according to Claim 12, characterized in that, when a break in movement is detected, the vectors of the preceding images are not considered.

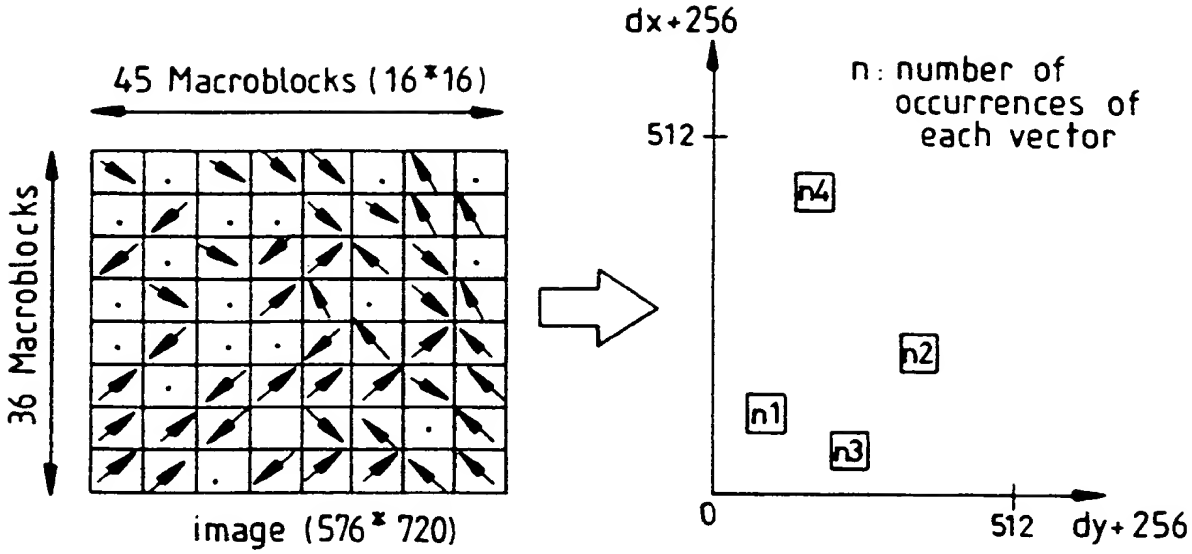
45 Macroblocks (16*16)
36 Macroblocks
image (576*720)
dx+256
512
n: number of occurrences of each vector
n4
n2
n1
n3
0
512
dy+256

FIG.1

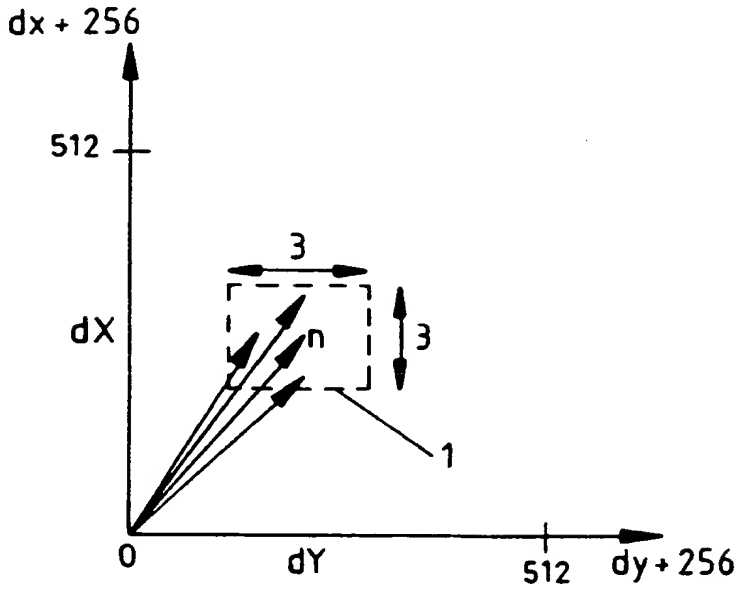
dx + 256
512
3
dX
n
3
1
0
dY
512
dy + 256

FIG.2

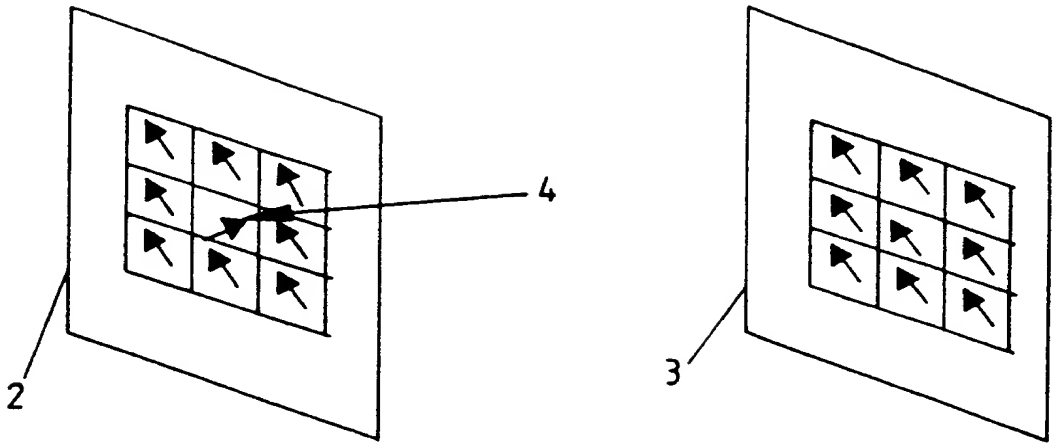

FIG.3

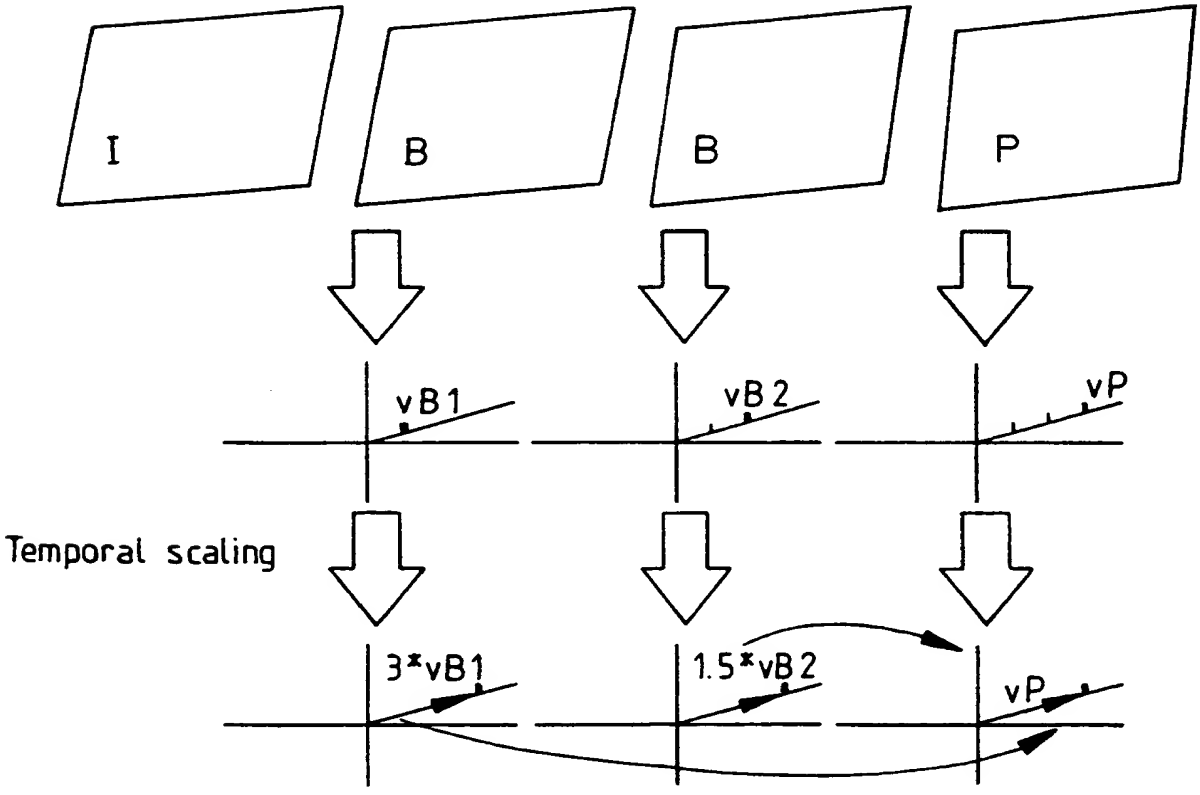

FIG.4

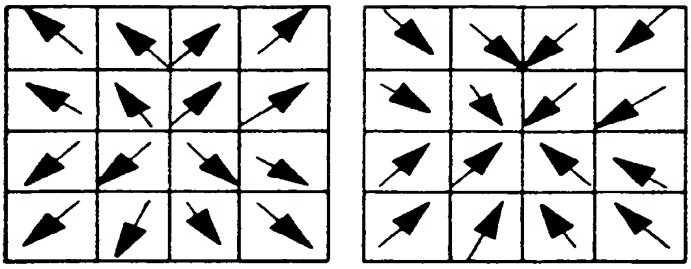

FIG.5

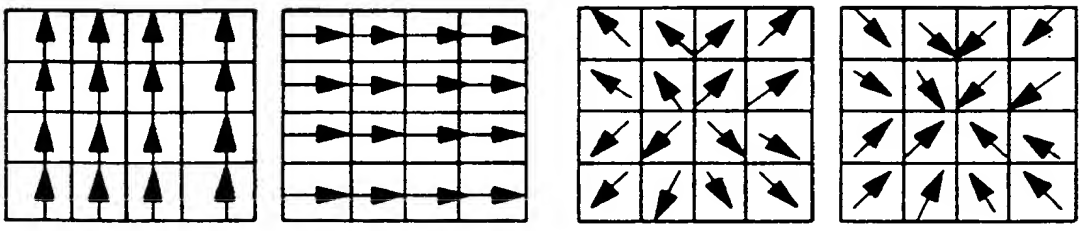

FIG.6